SpaceOps-2023, ID # 504

UTISS3: THE ISS UTILIZATION SERVICE PROVIDED BY ALTEC FOR ASI'S "MINERVA" MISSION AND FUTURE PAYLOADS

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Abstract

The Italian Space Agency (ASI) contributed in the design and development of the International Space Station (ISS) and still contributes in its Sustaining Engineering Support and Utilization. In the frame of the ISS Utilization, the Italian Space Agency has funded the development and the operations of several payloads and experiments in a broad range of areas: physics, biology, human physiology and technology demonstrations. Some of these payloads are also oriented to support the enabling of future human exploration in space.

Since December 2021, Aerospace Logistics Technology Engineering Company (ALTEC) has a contract with the Italian Space Agency to support the Italian Utilization on the International Space Station, named UTISS service, specifically UTISS3 for this contractual phase.

The main objective of this activity is supporting ASI and the PI/PDs in the development and mission integration of new payloads, including the definition, implementation and execution of the payloads' on-board operations and supporting ASI in the definition and exploitation of the Italian Research planning on ISS and the dissemination of ASI payloads' research results.

ASI has access to the ISS resources to exploit the Italian ISS utilization plan, by means of Space Agency Bilateral Accords, either through the Memorandum of Understanding (MoU) between ASI and NASA, for the use of the ISS dated 1997, and the ESA National Contribution program.

The implementation of the UTISS service for the development and mission integration of new payloads is similar for ESA and NASA, since the same ISS processes are applicable, while the counterparts are different.

Payloads that are developed and operated under the ASI/NASA MoU are integrated and operated interacting directly with NASA Payload Operations Center, while payloads developed and operated under ASI/ESA agreements are integrated and operated interacting directly with ESA Payload Integration Manager and the assigned User Support Operations Centre.

The above scheme was successfully implemented for the ASI "BEYOND" mission, increasing the contribution of the Italian research community to the ISS and is also being implemented for the ASI "Minerva" and further missions.

The implementation of the UTISS3 service benefits also of the involvement of ALTEC in other activities in support to the ISS: engineering support to the Permanent Multipurpose Module and Training, Logistics and Operations Support for Columbus, including the contribution to the Columbus Flight Control Team.

By means of the different contribution of ALTEC to the ISS, a single large ecosystem was built-up, composed of a series of mechanisms, processes, tools and all the above distributed skills, aimed at providing specialized services for the preparation and execution of the activities of the ISS, whether related to its use or the management of the orbital infrastructure and payloads' mission integration and operation, both within ESA and ASI and NASA.

The aim of this paper is to describe the set-up of UTISS3 service and the specifics of how it is carried out at ALTEC in synergy with the other services provide to ASI and ESA for the ISS. The paper will then describe its implementation for the "Minerva" mission payloads and the preparation for the further ASI payloads.

Keywords: payload, mission integration, operation, utilization, human space flight

Acronyms/Abbreviations

ADP: Acceptance Data Package
ALTEC: Aerospace Logistic Technology Engineering Company
AMS: Alpha Magnetic Spectrometer
AR: Augmented Reality
ASI: Italian Space Agency

ARD: Activity Requirement Document
BDC: Baseline Data Collection
CAD: Computer-Aided Design
CDR: Critical Design Review
CEF: Change Evaluation Form
CMC: Cargo Mission Contract
CoFR: Certificate of Flight Readiness
DSP: Data Sharing Plan
DSRS: Data Set Request & Status
EMC: Electro Magnetic Compatibility
ERD. Experiment Requirement Document
ESA: European Space Agency
ESR: Experiment Scientific Requirements
EVMS: Eastern Virginia Medical School
FAR: Final Acceptance Review
GDS: Ground Data Service
GSE: Ground Support Equipment
GSRT: Ground Support Requirement Team
HOSC: Huntsville Operations Support Center
HRMRB: Human Research Multilateral Review Board
HW: HardWare
ICB: Informed Consent Briefing
ICD: Interface Control Document
IRB: Institutional Review Board
IRD: Interface Requirements Document
IREST: ISS Resource Tracking Tool
ISD: ISS Scientific Data Directory
ISF: Investigation Summary Form
ISPARC: ISS Scientific Publication Archive
ISSMP: ISS Medical Project
JAXA: Japan Aerospace eXploration Agency
JSC: Johnson Space Center
KSC: Kennedy Space Center
MPRWG: Medical and Performance Risk Working Group
MSC: Mission Support Center
MSFC: Marshall Space Flight Center
NASA: National Aeronautics and Space Administration
NG: Northrop Grumman
PD: Payload Developer
PDR: Preliminary Design Review
PI: Principal Investigator
PIA: Payload Interface Agreement
PIM: Payload Integration Manager
P/L: PayLoad
PMM: Permanent Multipurpose Module
POC: Point of Contact
POIC: Payload Operations Integration Center
POIWG: Payload Operations Integration Working Group
PSRD/WSRD: Payloads / Wallops Support Requirement Document
QR: Qualification Review
SpX: Space-X
SRR: System Requirements Review
SW: SoftWare
UHB: User Home Base
UIB: Utilization Implementation Board
USOC: User Support and Operations Centre

VCD: Verification Control Document
VR: Virtual Reality
VUS: Volo Umano Spaziale

1. Introduction

The UTISS service is a contract to support the Italian Utilization on the International Space Station (ISS) and consists of the activities related to the engineering and logistics support service that the Italian Space Agency (ASI) needs for the definition and implementation of the Utilization Plan for the ISS and the design, development and operation of the selected Italian experiments.

The UTISS3 service is assigned to ALTEC since the end of 2021 and is mainly devoted to:

- Support ASI and the PI/PDs in the development and mission integration of new payloads
- Support the operations, including possibly the return, of the ASI payloads already on board the ISS
- Support the ASI function in charge of the Italian Research planning on ISS and the dissemination of ASI payloads' research results

The above service is implemented by ALTEC using a core team devoted to the day-to-day support, but also with the contribution of specialists in several disciplines available to support specific request and the availability of a Mission Support Center able to act as ASI User Support and Operations Centre (USOC) and support ASI ISS P/Ls' operation from Torino, Italy.

The industrial core team consists of:

- Program Manager: he is the person in charge of the organization and provision of the service
- Payload Manager: he/she is responsible to follow the design, development and qualification phases until the completion of the single payload activities. The Payload Manager is the interface for the analytical integration of the payload to NASA or ESA. The Payload Manager covers also the function of Payload Integration Manager (PIM), is the main technical point of contact between the PI/PD and the NASA or ESA PIM and provides all the information related to the engineering integration process of the experiment on the ISS and on the launch/re-entry vehicle
  A Lead Payload Manager is in charge to coordinate the activities of the Payload Managers, acts as technical interface for ASI and follows the activities related to the Basic Services Payloads
- PA&Safety Manager: he/she takes care of all aspects of Product Assurance and of the management of the Safety process in the context of P/L certification. In close cooperation with the Payload Manager, he/she is the interface between NASA or ESA Safety and the developer of the payload
- Logistics Manager: he takes care of all the management of the logistics aspects related to the handling of the payloads and will coordinate the shipping and/or return activities with the interfaces of the various integration, test and launch/return sites (e.g. PoC NASA / CMC)

The agency team consists of:

- ISS Utilization Manager
- Several Project Managers that follow the development of ASI P/Ls

UTISS service supports on behalf of ASI a number of new payloads selected in the frame of the ASI VUS tenders for "Technological researches and demonstrators on the ISS", in addition to the ones already on-orbit. A detailed description of the relevant activities can be found in the next sections of this paper.

For the Minerva Mission assigned to the Italian ESA astronaut Samantha Cristoforetti, ASI selected two of the new payloads: Antioxidant Protection (a.k.a. Prometeo) and OVOSPACE, that were integrated respectively with ESA and NASA.

In particular, ALTEC has provided support to the whole integration phase of Antioxidant Protection, including but not limited to:

- the provision of inputs and the coordination of documentation delivery to ESA and to NASA after their review
- the overall Safety process including the provision of inputs to NASA toxicologist upon the completion of Safety Review Phase III with ESA

- the order of labels
- the participation to periodic meetings and in the end
- the support to the Principal Investigator (PI) and Payload Developer (PD) during the integration activities at EVMS lab, in the area of the Mid-Atlantic Regional Spaceport in Eastern Virginia from where the NG-18 mission took-off

After the launch, ALTEC monitored the operations on-orbit and the return of Antioxidant Protection payload to the PI.

The OVOSPACE integration process was instead supported by Nanoracks, so the UTISS service for this payload was limited to the review and tracking of related ASI's Resources Utilization on the ISS and the support for the dissemination.

Unfortunately, due to a significant postponement of NG-18 launch w.r.t. the original Flight Plan, the two payloads were launched in November 2022, returned in January 2023 on SpX-26 and therefore not operated by Samantha Cristoforetti.

For the time being, the service has been started for five additional new ASI payloads that are already selected: four will be integrated with NASA and one with ESA, and some other payloads are already in pipeline to be started. These new payloads will be launched and operated tentatively in the Increments 70, 71 and 72.

On the other hand, during the Minerva mission, the Italian astronaut was able to operate other ASI payloads already on-orbit, namely Acoustic Diagnostics, NUTRISS, LIDAL and EVOOS, for which only basic service activities have been provided by ALTEC, as described in the following paragraphs.

2. Support for New Payloads

ASI has access to the ISS resources to exploit the Italian ISS utilization plan, by means of Space Agency Bilateral Accords, either through the Memorandum of Understanding (MoU) between ASI and NASA, for the use of the ISS dated 1997, and the ESA National Contribution program. In details, the MoU with NASA guarantees ASI the access to 0,85% of NASA resources, while the bilateral agreements with ESA are signed on a case-by-case basis.

The implementation of the UTISS service for the development and mission integration of new payloads is similar for ESA and NASA, since the same processes and requirements to fly a payload on the ISS are applicable, while the counterparts are different.

The major differences consist in the fact that payloads developed and operated under the ASI/NASA MoU are integrated and operated interacting directly with NASA MSFC's POIC, while payloads developed and operated under ASI/ESA agreements are integrated and operated interacting directly with ESA Payload Integration Manager and the assigned USOC.

The activities related to new experiments consist in providing to the Italian Space Agency the technical support in the preparation of input and products needed for the P/Ls' mission integration and operation execution. This includes also the support to the PI/PD during all phases of the experiment project, from development, to testing, to verification and finally to acceptance of the same.

For complex payloads, in order to ensure that these payloads are in line with NASA and ESA processes and contain the needed data, the UTISS service provides support for:

- the major project reviews, e.g. System Requirements Review (SRR), Preliminary Design Review (PDR), Critical Design Review (CDR), Qualification review (QR), Final Acceptance Review (FAR)
- the preparation of technical documentation, e.g. test specifications, test procedure, test report, analysis report, Design Definition Report, Acceptance Data Package (ADP)

The Payload development and integration activities are summarized below and showed in the Fig.1:

- Support to the development and manufacturing of the new payloads
- Support to the Mission Integration and Certificate of Flight Readiness (CoFR)
- Safety Management for launch and return
- Support to pre and post flight activities, e.g. P/L integration at launch site and Baseline Data Collection (BDC)
- Support to the on-board operations
- Logistics support

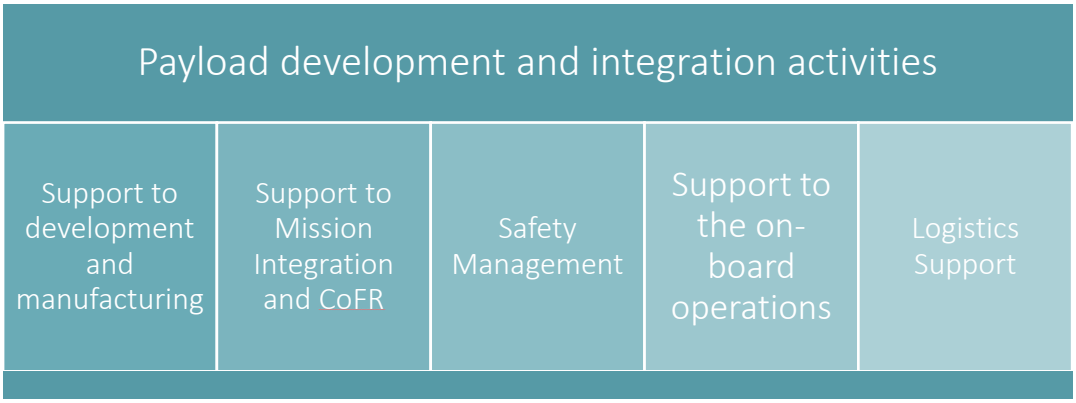

Figure 1: Payload development and integration activities

2.1 Support to Payloads' development and manufacturing and Mission Integration

The support for the development of a new payload begins with the completion of the feasibility assessment and finalization of operation scenario including the selection of the operational phase (ISS Increment) in which to operate it. This implies the evaluation of the characteristics of the payload, including its constraints, and the preparation of its integration into the increment.

Several documents, inputs and products have to be prepared and provided to NASA and/or ESA in order to describe the operational scenario, the experiment objectives, the benefits for in space and on ground activities, the parameters to be measured, the requirements to be met and the constraints to be taken into account.

Provisions of the above products, the Payload Interface Agreement (PIA) is defined and agreed. The PIA defines the support that NASA or ESA has to provide to ASI during the development, integration and operational phases to carry out the Payload in based on its technical characteristics, its mission requirements and any constraints.

In the early phase of payload project, that involves human subject, it is necessary also to collect a series of scientific and medical information to be submitted to relevant competent boards, to endure the ethical, safe and equitable treatment of the subject.

Based on the payloads' characteristics, the mission scenario and the facility in which they are operated, it is possible to identify the applicable requirements based on which the payload is developed, tested and verified and integrated into the ISS environment and in the launch/re-entry vehicle.

Starting from the applicable documents listing the interface requirements with the ISS, with the modules in which the experiment is operated and with the launch and re-entry vehicle, a matrix of applicability, i.e. the Interface Requirements Document (IRD), has to be defined selecting the applicable requirements and the P/L's Interface Control Document (ICD) has to be prepared.

Each requirement is verified based on the indicated or requested verification methods, in order to demonstrate its satisfaction.

To prepare the IRD, the list of HW and SW to be developed and/or used during payload operation has to be defined and provided, including the part name/description and part number of each element.

To qualify the payload for launch, operation and return from the ISS, all the checks necessary to demonstrate the fulfilment of the requirements made applicable through the IRD and the safety process have to be defined and executed.

During the qualification process, based on the applicable verification methods, tests (e.g. structural, thermo-vacuum, EMC…) and other verifications (e.g. analyses, inspections or review of design) are executed on the payload. In the case of complex experiments, a detailed test and verification plan is prepared to define the planning of the verification activities. In addition, specifications, procedures and test/verification reports are provided to demonstrate full compliance with the requirements. A Verification Control Document (VCD) is prepared as well.

As part of the support to the engineering integration, starting from the applicability matrix of the requirements and the related P/L ICD, it is also defined the list of the interface tests to be carried out and the data to be provided. Furthermore, such tests and verifications will be also completed by those deriving from the safety process.

In this phase, support is provided to NASA or ESA and PI/PD to define the applicable requirements and the verification methods necessary for their closure and to prepare and execute all the related activities.

Input for payload's manifesting and mission integration are prepared in this phase in order to provide information on the entire set of payload requirements for its operations on board, such as:

- crew time,
- power and data budgets,
- communication requirements in downlink and uplink
- pictures and videos needs
- payload upload, download and stowage requirements

In this phase, also the support for the preparation and revision of the documentation required by the integration and certification process (e.g. ICD/PIRN, Drawing Data Set, CoC, Data Verifications, CoFR Endorsement Package…) are provided.

At the end of the flight P/L certification process, support is provided in the preparation of the Certificate of Flight Readiness by collecting all the necessary inputs, both from an engineering and safety point of view, for the completion of the Stage Operations Readiness process Review (SORR), at the end of which the P/L will be declared ready for flight from all points of view (engineering, safety, operational).

The main areas for which a status needs to be provided are outlined below and will be applicable depending on the type and complexity of the experiment and the integrator, ESA or NASA:

- HW/SW Qualification
- Acceptance and product configuration
- Training, Operations & Ground Segment
- Safety
- Launch/Return site processing
- Pre-launch/Post-return processing, Baseline Data Collection (BDC)
- Maintenance and logistics

The CoFR inputs are continuously monitored during the development and integration phase, in order to promptly identify any critical issue or "showstoppers" and manage them.

2.2 Safety Management

The Safety process can be under NASA or ESA responsibility, based on the Agency integrating the P/L. In both cases, the certification process is based on the same standards and documents to be submitted, whereas the interfaces are different. In the case of NASA, the responsible for Safety is the Payload Safety Review Panel (PSRP), while for ESA is the ESA Safety Review Panel (ESRP).

The compliance of the payload with the applicable requirements guarantees the safety for everything that interacts with the payload itself: personnel, ISS and any Visiting Vehicles.

The Safety review process runs in parallel to the development of the Payload and takes place according to the methods and times established by the applicable ISS documents. Each Payload that has to be used on the ISS is generally subjected to four revision phases.

- Phase 0 (Concept design phase) – whose objectives are:
  - Identification of the Safety requirements applicable to the payload, preliminary identification of the risks associated with the Payload and their causes
  - Description of potential risks
  - Preparation of a Safety Data Package
- Phase I (Preliminary Design Review - PDR) – whose objectives are:
  - Obtaining the approval from the Payload Safety Review Panel (PSRP) of the update of the Safety analysis performed in Phase 0 based on the preliminary design (PDR level) and the mission scenario
  - Revision of all risks associated with the Payload and their causes and preparation of the related Hazard Reports
  - Identification of all methods of risk elimination, reduction or control
  - Preliminary definition of criteria for verifying risk elimination, reduction or control methods
  - Definition of Payload interfaces and definition of associated risks
  - Updates, as necessary, of the Safety Data Package

- Phase II (Critical Design Review - CDR) – whose objectives are:
  - Obtain approval from the PSRP of the update of the Safety analysis performed in Phase I based on the project maturity (CDR level) and the mission scenario
  - Revision of all risks associated with the Payload and their causes and updating of the related Hazard Reports
  - Definition and documentation of the implementation of criteria for verifying risk elimination, reduction or control methods
  - Definition of specific safety verification (test plans, analyses, inspections, etc.)
  - Definition of the mission (upload, increment and, if applicable, download scenario)
  - Update of the Safety Data Package with any new risks identified during the maturation of the project
- Phase III – whose objectives are:
  - Obtaining the approval from the PSRP of the update of the Safety analysis carried out in Phase II and the approval of the documentation of the results of compliance with the Safety requirements (Flight Safety Certificate)
  - Verification and validation of the results of the tests and analyses required by the various Hazard Reports
  - Identification of all the verifications still necessary for the conclusion of the process and insert them in the SVTL (Safety Verification Tracking Log) list

In case of P/L or parts that have already flown (Reflight) or composed of parts produced in series, a simplified Safety process (Simplified Serie/Reflight Certification, SSRC, process) is held, consisting in a unique Safety Review, very often "Out of the Board", a small SDP which includes the so-called Series/Reflight Safety Assessment (via the form ISS_OE_622) and the Flight Safety Certificate (ISS_OE_906).

In order to address and identify potential hazards associated with ground operations at the launch site, the preparation of a Ground Safety Data Package (GSDP) may be required and subjected to a similar process defined for the FSDP. Ground Safety Reviews (GSR) are managed directly by the launch site Safety team, where the Ground Safety Review Panel (GSRP) is located.

In case of P/Ls that present a zero or low level of risk associated with the activities to be carried out on ground at the launch site, or in any case with very limited ground processing activities, a Ground Safety Check List may be submitted instead of the GSDP.

The Payload must also be certified for the return to the ground phase, meaning the need of a Flight Safety Certificate which authorizes its boarding on the vehicle foreseen for the return.

2.3 Operation Support

The Operation Support is provided for each phase of the mission: pre-flight, on orbit and post-flight.

Operation concept and procedure

During the development and the mission integration of the payload, UTISS service provides support in the definition of the on-ground and on-board operations, also in terms of duration, sequence and needed resources.

In particular, the following elements are defined:

- Definition of the operational concept, starting from the scientific objectives defined by the PI/PD and the adopted scientific protocol
- Definition of how the crew interfaces with the payload: these can be extremely variable and range from a complex interaction, which requires deep technical expertise from the crew, up to a limited and standard interaction which may imply the activation of the payload, a limited monitoring during the execution and the shutdown once the experiment is concluded
- Definition of the data acquisition process (e.g. downlinks of payload's data, downlinks of images, filling in of questionnaire by the crew, return of samples or hardware for post-flight analysis). Each process has specific requirements that must be met to ensure that the scientific objectives of the payload is achieved.
- Definition of the experimental sessions to be performed in orbit, sequence and temporal definition which must be carefully defined in advance to be integrated into the ISS timeline
- Definition of the tasks to be performed by the crew and of any critical aspects from an operational point of view, situations that can endanger the conduct of the experiment or have impacts on the ISS operations

All these elements constitute inputs for the development of the operational products (e.g. payload regulations, flight rules, operational timelines, detailed operational procedures…) and the procedures for the payload execution.

The procedures are developed by NASA/ESA experts, applying compliance with ODF (On-board Data Files) standards, as regards the involvement of both the crew and the ground controllers. Once the procedures have been prepared, they are reviewed together with the PI/PD to ensure that they envelope all the elements essential to conducting the experiment.

Once frozen, the procedures become an integral part of the training of the crew that will perform the on-orbit operation.

Crew training definition and execution

The development and execution of the training is an activity that both NASA and ESA sides involves the training team, the operational team and the UTISS service that support the PI/PD for the preparation of all the necessary inputs and acts as an interface with the involved teams.

The training support starts defining the training requirements and strategy for the payload, based on the operational scenario and constraints. Once the training is confirmed to be necessary, the following activities are foreseen to support the definition of its preparation and execution:

- Contribute to the definition of the type of training to be performed (on ground, on orbit, familiarization only)
- Support the PI/PD in the preparation of the documentation necessary for the preparation of the training material
- Contribute with the PI/PD to the definition of the training model adopted based on the complexity of the payload

On-ground operation support

If the payload required pre-flight ground operations at the launch site, the UTISS service provides the necessary support for the definition and collection of the requirements and the integration activities to be performed before the launch.

This implies also the coordination of both laboratory operations and the logistics of incoming and outgoing material.

Support is also provided for compiling the PSRD/WSRD and for drafting the procedures necessary for:

- preparation and integration of the experiment at KSC/EVMS before launch
- verification and tests at the launch site
- preparation of post-integration reports

On-orbit operation support

The payload on-board operation may or may not involve the crew and as well may or may not require dedicated support from ground.

In case of operations that need support from ground, the ASI payloads on-orbit operations can be followed by the ALTEC Mission Support Center (MSC), hosted in Torino, which is permanently connected to the ISS to provide engineering support to the PMM module.

The center is equipped with several consoles set-up for receiving and displaying telemetry data, voice loops and video connection to the ISS.

For ASI Payloads' operations, the services needed to follow up the operations are provided by MSFC's Payload Operations Integration Center (POIC) and can be available at ALTEC's MSC remotely as well as at the User Home Base (UHB) set up (e.g. PI /PD premises…).

The preparation of these services starts from the definition of the requirements for ground operations (data & communication) to be provided to the Ground Support Requirements Team (GSRT) which integrates and consolidates all the requests and coordinates the approval of the final plan with the various involved agencies.

The Ground Data Service (GDS) requirements, to be submitted via the GDS Blank Book Tables, contain all the information necessary for the GSRT to implement the service that the POIC will provide and also the resources that the HOSC will make available.

In addition to the requirements necessary to implement the service, a reference schedule has to be provided so that everything is ready for the CoFR.

Ground data service requirements are already tracked in the payload-unique PIA.

Since ASI is considered as an International Partner, a permanent interface between POIC and ASI USOC has been established through which all services are provided. The ASI Operational Network (ASINET) provides the interconnectivity among the centres.

While this interface set-up provides the general services for all payload , it is within the Ground Data Services Blank Book that it is defined and described, for each single payload and/or experiment, what services are used and by whom.

Therefore, during the operations of the ASI payloads, the UTISS members of ALTEC personnel can follow the operations from the MSC. The interactions with the payload can be foreseen at different levels:

- receiving Health & Status data
- receiving scientific data
- sending of commands
- video monitoring
- voice loop interaction with POIC
- interaction via voice with astronaut

The Mission Support Center in ALTEC has the possibility of setting up the connection via voice loop and receiving data and images of the payload from the ISS, as requested and agreed during the definition phase of the payload operations.

If the payload is connected to an ISS data link, it is possible to receive information on the status of the payload (Health & Status) and the related scientific data on the ground.

Nominal operations do not involve sending commands to the payload, but if remote control is needed a special interface can be implemented from the center in ALTEC to transmit them directly to the payload, again through the HOSC.

Operations with the payload, even if they do not involve the astronaut but are limited to telemetry and remote controls, can still require real-time interaction with the POIC, as long as the payload is operative. For this purpose, it is possible to implement a voice connection (e.g. by means of IVoDS system).

In case of operations with the astronaut, it will even be more necessary to participate in the voice loop during the activities on the payload, in order to be able to provide support in case of problems or questions from the astronaut.

Figure 2: Support to ASI payload's operations from ALTEC MSC

In addition to the possibility of following the sessions of the payloads at ALTEC, according to the specific operational needs of the PI/PD, it is also possible to equip the PI/PD with a series of tools that allow the support of the experimental sessions execution directly from their premises (UHB).

The UHB setup can also be envisaged if the experiment is integrated by ESA and performed on Columbus, therefore through the reference ESA-USOC.

Post-flight Operation Support

Post-flight Operations can be summarized as follows:

- Support for the management of the return of the payload to the PI/PD
- Support for recovery and dissemination of experimental data and samples
- Support for BDC post-flight session support
- Support for preparation of lessons learned and crew debrief participation
- Support to ASI for updating experimental data and tracing resources used on related databases

2.4 Baseline Data Collection

Baseline Data Collection (BDC) sessions are an integral part of most life science experiments within the ISS that directly involve astronauts as passive and/or active executors of the experiment itself. They, therefore, support the experimental protocols implementation, making available important data collected in the pre- and post-flight phase, that are used as reference levels of the physiological and psychological parameters, in order to trend the variations over the time and/or the return to such levels.

The Baseline Data Collection sessions include set-up of tests, evaluations and/or medical examinations whose results, together with the results of the on-orbit phase, lead to the formulation of the answer to the scientific question at the basis of the experiment itself.

BDC activities involving astronauts must be described and presented in the medical board contexts for subsequent board approval and must be considered in all the contexts of augmentation goal preparation and planning.

The Mini-ED represents the first input for the dedication and planning of the BDC plan.

Once the experiment is approved and the astronaut has signed the informed consent, the BDC activities are planned and the BDC plan is prepared.

In addition to the above activities, support to the PI/PD is provided during the execution of the BDC sessions.

2.5 Logistics support

Logistics support to the PIs/PDs is provided for the definition, planning and execution of transport of the various Payloads:

- to the different NASA test and integration sites (JSC - Houston, in the case of "nominal load"; KSC - Kennedy Space Center for the launches of the Space-X rocket or Wallops Island for the launches of the Northrop Grumman rocket, in the case of "late load")
- from the test and de-integration sites (KSC – Kennedy Space Center, in the case of "Early Retrieval Item" or JSC – Houston, in case of "Nominal Cargo") to the PI laboratory or alternate site identified.

The process to perform these activities foresees an involvement already in the definition/planning phase of the mission relating to the Payload in order to be able to evaluate any peculiar and critical aspects of the shipment, e.g. if the material to be shipped is classified as Dangerous Goods or requires specific export licenses or import permits.

The knowledge of the technical characteristics and the identification of the transport requirements is decisive for the definition of the type of transport, the suitable packaging and labels and the documentation to be produced.

UTISS Service supports also the preparation of the shipping documentation both required by the international transport regulations (e.g. Proforma Invoices, Export / Import Mandates, Declaration of free export / import, DGR ...), and by NASA (e.g., DD1149, Part Tag...). When requested, a direct interface with NASA and the shipper/recipient, appointed by the PD/PI, is established to simplify and facilitate the transport process. In addition, in the case of shipments back from the de-integration sites, the information necessary to export the goods from the United States and to prepare the transport (e.g. Proforma Invoice, classification of the goods for Export Control and Customs Operations...) is provided to NASA.

2.6 Payloads under development and mission integration

The development and mission integration support has started for the following 5 payloads: IRIS, Aphrodite, Drain Brain 2.0, NAVCOM and SpaceSpinning. The first 4 payloads will be integrated and operated by NASA, while the

latter one by ESA. In this section we provide a brief overview of each payload and the development/mission integration status up-to-date:

- IRIS (Large area, wearable Ionizing Radiation dosimeters for real-tIme space crew perSonal monitoring): the novel IRIS ultralightweight and low voltage wearable radiation dosimeters realized by INFN-TT lab at University of Bologna will be used to monitor in real-time the dose received by each crew member. IRIS dosimeters detect both protons and X-gamma rays and will be the first quantitative real-time meters for personal crew dosimetry, able to operate 24/7 and follow crew member in all their activities. Data acquisition will be real-time, while the data transmission to ground will occur at the end of each of the three foreseen measurements sessions. Validation of IRIS dosimeters is done by post-fight comparison with data acquired from the ISS on-board radiation detectors, positioned in fixed location (e.g. ALTEA, LIDAL, DOSIS)
- APHRODITE (Autonomous PHotosensing Reusable On-board Device for Immunological Tests Execution): it is an autonomous portable device realized by University of Bologna that can check crew members' easily collectable biosamples, such as saliva, using an autonomous and simple-to-use analytical device which employs disposable and ready-to-use analytical cartridges directly within ISS, rather than collecting and storing samples for analysis upon their return to Earth. The device's first purposes are to monitor immune system impairment and stress levels among crew members.
  The availability of the developed analytical device is beneficial not only for space applications, but also for any kind of critical situations on Earth (e.g., emergency medicine, bioterrorism, diagnostics in developing countries, etc…)
- Drain Brain 2.0: this project is the upgrade of a strain-gauge plethysmography system realized by University of Ferrara, so as to investigate cerebral drainage and cardiac efficiency in humans through the detection of the so-called Jugular Venous Pulse, whose waveform is an indicator of cardiac function and a prognostic factor in chronic heart failure. Cerebral circulation in the human being, including the venous outflow mechanisms from the skull, is one of the major regulators of the brain physiology but very little is known about the mechanisms ensuring blood outflow from the brain in a condition of microgravity. Such instrumentation is also ideal to investigate patients with vascular diseases, because it is not operator-dependent and non-invasive, and by means of our research proposal we aim to integrate knowledge and data coming from experiments in different gravitational conditions
- NAVCOM: The NAVCOM Testbed is developed by QASCOM, based on the GARSPACE solution, a highly configurable space receiver developed for the board Analog Devices ADRV9361-Z7035 SDR. It is a Software Defined Radio (SDR) platform tested using a state-of-the-art System on Chip (Xilinx Zynq 7035) technology. The receiver will be connected to the ISS facilities using the serial and RF communication interfaces. It shall provide PNT services to the ISS from ranging signals transmitted from ground stations on Earth. It will demonstrate capability of supporting precise navigation applications on the Moon

Until now, UTISS has provided its support for these four P/Ls reviewing the following documents - PIA, ISF, 1-pager - and contributing to the Safety TIM phase 0. UTISS team is supporting the PI/PD in the review of the applicable safety and integration requirements identified by NASA, in order to collect all the information needed to design the HW in compliance with the SSP 57000 requirements. In addition, excluding NAVCOM which does not foresee crew involvement, the Mini ED has been prepared, while the protocol for IRB approval and Informed Consent of the crew is on-going.

- SpaceSpinning: The SpaceSpinning project led by CIRI AEROSPACE at University of Bologna aims to demonstrate the functioning of the electrospinning process in a space environment, and therefore in the ISS environment, by developing two types of tests with increasing complexity: the first set of experiments will be carried out by making simple polymeric nanofibers, while the second set of experiments will concern the realization of composite nanofibers. The realization of simple nanofibers will verify the stability and control of the electrospinning process in a non-terrestrial environment. The realization of composite polymeric nanofibers, i.e. nanofibers that incorporate nanoadditives, has the purpose of verifying the quality of the process and the quality of the nanofibers produced in conditions of microgravity. Both types of experiments will qualify the process and the materials that, in perspective, can be used in space and provide key scientific information to understand some phenomena related to the gravity that it has not yet been able to study on Earth

For this fifth payload UTISS is providing support for the identification of physical and technical constraints in the dimensioning phase of the prototype due to upload and stowage limitations and for the review of ARD requested by ESA.

3. Basic Service Activities

The basic service activities consist of the support to operation and maintenance of payloads already on-board, scientific divulgation and results dissemination and support to ASI function dealing with the ISS Utilization.

3.1 Support to operations and maintenance of P/Ls already on-board

The payloads object of the activities are AMS (Alpha Magnetic Spectrometer) and IN SITU (ISS Non-invasive Sample Investigation and results Transmission to ground with the Utmost easiness).
So far, the activities performed are the following:

- AMS: set-up of the ancillary data collection in terms of ISS position and attitude, processing daily the data and provision to the Italian PoC of the scientific community. In this frame, ALTEC has revised and validated the pipelines and tools used to retrieve and distribute the ISS telemetry data to the community in the requested reference system according to the specifications of the scientific team
- IN SITU: the P/L has just returned on-ground with SpX-26 and UTISS provided to NASA and the PI all the support for the return preparation: review of related Change Evaluation Form (CEF), input for manifest return, electronic Launch Return On-Orbit Disposition (eLROD), electronic Return Manifest Disposition Plan (eRMDP), submission of export request and performing of Safety Assessment for return

3.2 Support to scientific outreach and dissemination of results

In the frame of the UTISS service, it is requested to support ASI and the Italian scientific community with the identification of opportunities for the ISS exploitation for utilization purposes, to assess potential opportunities to promote and outreach the ASI utilization activities and to share the results of ASI P/Ls' research activities.

This is performed mainly through the regular participation to ISS meetings and activities (e.g. MPRWG, POIWG), identification and support to congresses, interaction with the operations and scientific community.

The activity implies also the maintenance and the updating of the online ASI archive (IREST, ISPARC and ISD), tracking the use of on-board resources assigned to ASI (ISS Resources Utilization Tracking Tool - IREST), describing the experiments and listing the publications (ISS Scientific Publication Archive - ISPARC) and data collected during the experiment sections (ISS Scientific Data Directory - ISD).

This activity is in strict collaboration with the ASI ISS Utilization function.

4. Synergies of ALTEC implementation of UTISS service

The implementation of the UTISS3 service benefits of the involvement of ALTEC in other activities in support to the ISS: engineering support to the Permanent Multipurpose Module and Training, Logistics and Operations Support for Columbus, including the contribution to the Columbus Flight Control Team.

By means of the different contribution of ALTEC to the ISS, a single large ecosystem was built-up, composed of a series of mechanisms, processes, tools and all the above distributed skills, aimed at providing specialized services for the preparation and execution of the activities of the ISS, whether related to its use or the management of the orbital infrastructure and payloads' mission integration and operation, both within ESA and ASI and NASA.

In the provision of TLO services for ESA and PMM Engineering Support for ASI, there are some processes where ALTEC is involved in an absolutely complementary way to what is required for UTISS, hereafter reported:

- Training Astronauts and Ground Staff: for ASI payloads to be integrated with ESA, ALTEC is also involved in the implementation of identified training's needs
- Integrated Logistics: in particular, ALTEC deals with the end-to-end management of the ESA cargo, therefore including the ASI experiments processed by ESA
- ECOS (EAC Crew Operations Support): for TLO, personnel are provided for the ECOS team who are responsible for operating some Payloads, as happened for example for Acoustic Diagnostics, thus probably often resulting in the operational counterpart of the UTISS team
- BDC: for TLO, ALTEC provides the coordination activities of the Baseline Data Collections performed by ESA, and therefore will be the counterpart of the UTISS team in the case of ASI experiments operated in agreement with ESA

- CM Desk: ALTEC, under the PMM contract, manages the SSCNs that come from NASA configuration management. Being able to manage all the SSCNs in the same office certainly optimizes the process and improves its efficiency and quality, also in relation to the interfaces with ASI and NASA
- Presidium of the ASI office at the JSC: ALTEC already has a resident for the PMM contract, which has now been operating for over 20 years in a fully integrated way with the NASA and international ISS teams at the JSC. This figure also becomes part of that ecosystem, of that mechanism made up of an integrated team of experts, knowledge and processes related to the ISS projects in which ALTEC is involved. This will allow, also for the UTISS team, continuous support capable of responding promptly to any type of need that may arise even in contingency situations. A further advantage is represented by the possibility, even in complex situations such as those caused by the COVID-19 pandemic, of having an access channel to the USA not easily obtainable otherwise
- The Mission Support Center, located at ALTEC since 2001, is as well daily used to retrieve ISS data from NASA Ops History for the Sustaining Engineering of PMM and can make available its capabilities to ASI for the automatic execution of processing pipeline of data needed for its payloads.

5. Conclusions

The UTISS contract is a fundamental asset for the Italian Space Agency and the Italian industrial, academic and research partners to have a safe and reliable process to access the ISS resources and achieve the best results in terms of utilization and outreach. This service guarantees safe and timely development, integration, operations both on board and on ground of the Italian Payloads, including the support to the dissemination of ASI utilization activities and to share the results of ASI P/Ls' research activities.

UTISS service is performed in an efficient way thanks to the synergy with other service contracts held by ALTEC with ESA, Training, Logistics and Operations (TLO) support to Columbus and with ASI for the sustaining Engineering of PMM.